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Forests of Pennsylvania.

By J. T. Rothrock, Botanist Member of the Pennsylvania Forestry Commission.

(Read before the American Philosophical Society, March 2, 1894.)

Exact statistics as to the forest area are as yet not available for the State of Pennsylvania. It is true that we can speak with some certainty of the area of our State which is devoted to farming interests. Deducting this from the known area of the State would, however, still leave us very wide of an exact statement as to the area actually covered by a growth of wood which is now, or ever will be, productive forest land. There would remain unaccounted for the space covered by cities, towns and villages; by mines, where the surface is allowed to remain unutilized because the wealth below dwarfs its importance, and because the surroundings are not favorable to production of trees; and lastly there would remain the fact that an enormous percentage of the reputed woodland is now producing timber of the slowest growing and least valuable kinds of wood, if indeed it should be designated as wood at all. It will be, however, an approximate statement, based upon the reports of our assessors for the year 1892, to say that we have accounted for 16,359,387 acres of cleared land, and 9,159,826 acres of woodland. This will at least fairly represent farming land, and the area covered by woody growth of some kind, and may afford a basis for computation as to the condition of things which *should* exist. By the above statistics we may account for about 25,555,500 acres of farm and woodland. This, however, leaves from four to six millions of acres of our State area to be accounted for as coming neither under farming nor forest conditions at present. Nominally we have nearly 36 per cent. of our area in trees, if we accept our assessors' statements as a basis of calculation.

For convenience sake this paper will be divided thus :

- I. The Kinds of Timber-producing Trees in Pennsylvania.
- II. Most Important Timber-producing Areas in Pennsylvania.
- III. Configuration of the State in Relation to Growth of Timber.
- IV. Rates of Growth of Most Important Kinds of Timber.
- V. Obstacles to the Growth of Timber.
 - (a) Natural Obstacles.
 - (b) Obstacles due to Human Agencies.
- VI. Relation of the Commonwealth to Forest Restoration.
- VII. Methods of Forest Restoration.

I. THE KINDS OF TIMBER-PRODUCING TREES IN PENNSYLVANIA.

The list of such trees indigenous to our State, which are of sufficient size, or in sufficient abundance to be of commercial importance, numbers seventy-eight species and is as follows :

- 3 *Magnolia glauca* L. Sweet bay, or swamp laurel.
 2 *Magnolia acuminata* L. Cucumber tree.
 3 *Magnolia tripetala* L. Umbrella tree.
 1 *Liriodendron tulipifera* L. Tulip poplar.
 2 *Tilia Americana* L. Basswood.
 2 *Tilia heterophylla* Vent. White basswood.
 3 *Ilex opaca* Ait. American holly.
 3 *Ilex monticola* Gray. Mountain holly.
 3 *Æsculus octandra* Marshall. Sweet buckeye.
 3 *Æsculus glabra* Willd. Ohio buckeye.
 3 *Acer Pennsylvanica* L. Striped maple.
 1 *Acer saccharinum* Wang. Sugar maple.
 2 *Acer dasycarpum* Ehrh. White, or silver maple.
 2 *Acer rubrum* L. Red, or swamp maple.
 3 *Negundo aceroides* Mœnch. Box elder.
 3 *Rhus typhina* L. Staghorn sumach.
 1 *Robinia pseudacacia* L. Locust.
 3 *Gymnocladus Canadensis* Lam. Kentucky coffee tree.
 3 *Gleditschia triacanthos* L. Honey-locust.
 3 *Prunus Americana* Marshall. Wild yellow, or red plum.
 3 *Prunus Alleghaniensis* Porter. Allegheny plum.
 3 *Prunus serotina* Ehrh. Wild black cherry.
 3 *Pyrus coronaria* L. Crab apple.
 3 *Pyrus Americana* DC. American mountain ash.
 3 *Cratægus coccinea* L. Scarlet haw, or whitethorn.
 3 *Cratægus punctata* Jacq. Blackthorn, or pear haw.
 3 *Cratægus Crus-galli*. Cockspur, or Newcastle thorn.
 3 *Liquidambar Styraciflua* L. Sweet-gum tree, or bilsted.
 3 *Cornus florida* L. Dogwood, or flowering dogwood.
 3 *Cornus alternifolia* L., f. Alternate-leaved dogwood.
 2 *Nyssa sylvatica* Marshall. Sour-gum, tupelo, pepperidge.
 3 *Oxydendrum arboreum* DC. Sorrel-tree, sour-wood.
 2 *Diospyros Virginiana* L. Persimmon.
 1 *Fraxinus Americana* L. White ash.
 2 *Fraxinus pubescens* Lam. Red ash.
 2 *Fraxinus viridis* Michx., f. Green ash.
 2 *Fraxinus sambucifolia* Lam. Black, hoop, ground, or water ash.
 3 *Chionanthus Virginica* L. Fringe tree.
 2 *Catalpa bignonioides* Walt. Catalpa, Indian bean, cigar tree.

This tree is not a native of Pennsylvania, but is becoming rapidly and generally naturalized, and is likely to be of considerable importance. For this reason I have included it in my list.

- 2 *Sassafras officinale* Nees. Sassafras.
 2 *Ulmus fulva* Michx. Slippery elm, red elm.
 1 *Ulmus Americana* L. White elm, American elm.

- 2 *Celtis occidentalis* L.....Hackberry, nettle tree.
 2 *Morus rubra* L.....Red mulberry.
 2 *Platanus occidentalis* L.....Buttonwood, sycamore.
 2 *Juglans cinerea* L.....Butternut, white walnut.
 1 *Juglans nigra* L.....Black walnut.
 1 *Carya alba* Nutt.....Shellbark, or shagbark hickory.
 2 *Carya sulcata* Nutt.....Big shellbark, king nut.
 1 *Carya tomentosa* Nutt.....White-heart hickory, mocker nut.
 1 *Carya porcina* Nutt.....Pig-nut, or broom hickory.
 2 *Carya amara* Nutt.....Swamp hickory, or bitternut.
 2 *Betula lenta* L.....Cherry, sweet, or black birch.
 2 *Betula lutea* Michx. f.....Yellow, or gray birch.
 2 *Betula populifolia* Ait.....White birch.
 2 *Betula papyrifera* Marshall.....Paper, or canoe birch.
 2 *Betula nigra* L.....Red, or river birch.
 3 *Ostrya Virginica* Willd.....Hop-hornbeam, leverwood.
 3 *Carpinus Caroliniana* Walter.....Hornbeam, blue, or water beach.
 1 *Quercus alba* L.....White oak.
 2 *Quercus stellata* Wang.....Post, or iron oak.
 2 *Quercus macrocarpa* Michx.....Bur oak, overcup oak.
 2 *Quercus bicolor* Willd.....Swamp white oak.
 1 *Quercus Prinus* L.....Chestnut oak, rock chestnut oak.
 1 *Quercus Muhlenbergii* Engelm.....Yellow oak, chestnut oak.
 1 *Quercus rubra* L.....Red oak.
 1 *Quercus coccinea* Wang.....Scarlet oak.
 1 *Quercus coccinea* var. *tinctoria* Gray.....Black, or yellow-barked oak.
 2 *Quercus palustris* Du Roi.....Swamp, or pin oak.
 3 *Quercus falcata* Michx.....Spanish oak.
 3 *Quercus nigra* L.....Black jack, or barren oak.
 3 *Quercus imbricaria* Michx.....Laurel oak, shingle oak.
 3 *Quercus Phellos* L.....Willow oak.
 1 *Castanea sativa* Mill. var. *Americana*
 Gray.....Chestnut.
 3 *Castanea pumila* Mill.....Chinquapin.
 2 *Fagus ferruginea* Ait.....Beech.

There appears to be no native willow of sufficient importance to merit a place in this list.

- 1 *Pinus Strobus* L.....White pine.
 1 *Pinus rigida* Miller.....Pitch pine.

Under the pitch pine the Pennsylvania lumberman groups what he recognizes as yellow and jack pine.

- 2 *Pinus pungens* Michx., f.....Prickly pine, poverty pine, table mountain pine.
 2 *Pinus inops* Ait.....Jersey, or scrub pine.

- 3 *Pinus mitis* Michx.....Short-leaved yellow pine, yellow pine.
 2 *Pinus resinosa* Ait.....Norway pine, red pine.
 2 *Picea nigra* Link.....Black spruce.
 1 *Tsuga Canadensis* Carr.....Hemlock.
 2 *Abies balsamea* Miller.....Balsam, balsam fir.
 2 *Larix Americana* Michx.....Hackmatack, larch, tamarack.
 2 *Thuja occidentalis* L.....Arbor vitæ.

The above trees I have divided into a first, second and third class, and designated the class by a corresponding figure to the left of the name. Commercial importance and abundance are made the basis of this artificial classification: the only merit of which is that it will serve to impress certain leading facts.

The nomenclature adopted is that of Gray's *Manual of Botany*, which will remain the popular authority until superseded by a more modern book.

II. MOST IMPORTANT TIMBER-PRODUCING AREAS IN PENNSYLVANIA.

The words, "most important" timber-producing areas, are, of course, in one sense, relative, because they carry a twofold meaning, *i. e.*, important as to quantity produced, and important as to the uses made of each kind of wood. In one sense we might consider hemlock and white pine the most important for Pennsylvania; because the former is a characteristic tree of our State, and the latter one of immense commercial importance. We shall, however, use the words more especially in regard to the quantities produced on land which may be regarded as by nature better adapted to the growth of timber trees than to any other purpose.

This would naturally suggest the mountain areas of the Commonwealth. It must be remembered, however, that an exclusive consideration of these regions would practically exclude the soil on which our best white oak, black walnut, ash, tulip poplar and linden have grown. Furthermore, land now of more value for agricultural purposes than for any other uses might by some change in price of crops, or by other commercial perturbations, be ultimately found of greater value in production of some quick-growing kind of timber. This chance is quite within the limits of possibility in the case, for example, of the chestnut tree, if the fruit should ever become, as in Southern Europe, an important article of food and a stimulus be given to the production of choice varieties of the tree. Indeed it is by no means certain that we shall not very soon have an example in the increased demand for young chestnut as a source of supply for tannin.

Extending northeast from the southern border of the State through the central third is a region of varied topographical characters. Much of it is mountainous and rocky, and but for the possible discovery of mineral resources, and those already known, is of no value except for the growth of timber. The actual area of the land of this character is not yet

accurately determined, though it will probably aggregate not less than 5000 square miles. Once the timber is removed from such land, under present conditions it becomes not only an unproductive area to the State, but too frequently a nursery of floods during the time of melting snows and in periods of unusual rainfall. The Commonwealth has, therefore, a double inducement to restore it to its normal condition, either by direct care, or by such wise legislation as will enable the owners to do so.

What this legislation will, or, should be, depends very largely on the condition of the owners of this timber-producing area. For example, in the State of New York the mountain areas—Adirondacks and Catskills—are comparatively isolated. State possession there seems not only the probable, but the natural thing, when one considers that these same mountain regions are most important as water sheds for the eastern parts of that Commonwealth.

On the contrary, in this State the mountain areas are quite too large to encourage the idea that they ever will, or ever should, become the property of the State. In short, they will most likely remain in the hands of the small land holder, and the legislation intended for such areas must, from the nature of the case, be chiefly adapted to his needs.

Considering the counties of the State alphabetically, it appears that the cleared and the forest acreage of the Commonwealth is as follows :

Table Showing what Percentage of the Entire Acreage of Each County is Timber Land.

COUNTIES.	CLEARED LAND.	TIMBER LAND.	ENTIRE ACREAGE.	PER CENT.	CLASSIFICATION.			
					% 25	% 50	% 75	100
1 Adams	251,637	55,571	307,208	18	18			
2 Allegheny.	22,422							
3 Armstrong	296,111	87,713	383,824	22.8	22.8			
4 Beaver	196,616	59,214	255,830	23.1	23.1			
5 Bedford.	330,059	234,277	564,536	41.5		41.5		
6 Berks.	430,516	82,790	513,306	16	16			
7 Blair	141,997	154,292	296,289	52			52	
8 Bradford	468,350	204,131	672,481	30.3		30.3		
9 Bucks	350,364	19,151	369,515	5.2	5.2			
10 Butler	365,672	103,528	469,200	22	22			
11 Cambria	322,394	73,507	395,901	18.5	18.5			
12 Cameron	34,072	189,381	223,453	84.7				84.7
13 Carbon	82,646	109,744	192,390	57			57	
14 Centre	189,580	124,107	313,687	39.5		39.5		
15 Chester	389,305	52,474	441,780	11.2	11.2			
16 Clarion	284,471	75,378	359,849	20.9	20.9			
17 Clearfield	177,227	477,978	655,205	72.9			72.9	
18 Clinton	148,957	405,881	554,838	73.1			73.1	
19 Columbia	186,808	100,426	287,234	34.9		34.9		
20 Crawford	425,103	180,600	605,703	29.8		29.8		
21 Cumberland	231,161	40,057	271,218	14.7	14.7			
22 Dauphin	213,768	102,972	316,740	32.5		32.5		

COUNTIES.	CLEARED LAND.	TIMBER LAND.	ENTIRE ACREAGE.	PER CENT.	CLASSIFICATION.			
					% 25	% 50	% 75	100
23 Delaware	110,000	11,500	121,500	9.4	9.4			78.6
24 Elk	107,611	395,420	503,031	78.6				
25 Erie	403,722	47,264	450,986	10.4	10.4			
26 Fayette	302,274	157,565	459,839	34.2		34.2		
27 Forest	139,501	138,393	277,894	49.8		49.8		61.4
28 Franklin	291,044	134,250	425,294	31.5		31.5		
29 Fulton	114,172	182,636	296,808	61.4				
30 Greene	341,607							
31 Huntingdon	259,416	229,390	488,806	46.9		46.9		56
32 Indiana	342,455	138,916	481,371	28.8		28.8		
33 Jefferson	200,565	187,985	388,550	48.3		48.3		
34 Juniata	139,182	77,122	216,304	35.6		35.6		
35 Lackawanna	237,622	31,796	269,418	11.8	11.8			52.8
36 Lancaster	512,169	57,148	569,317	10	10			
37 Lawrence	186,793	19,221	206,014	9.3	9.3			
38 Lebanon	173,692	38,941	212,633	18.3	18.3			
39 Lehigh	185,620	16,492	202,112	8.1	8.1			56
40 Luzerne	300,000	382,400	682,400	56				
41 Lycoming	400,000	306,000	706,000	43.3		43.3		
42 McKean	387,088	230,371	617,459	37.3		37.3		
43 Mercer	361,666	39,670	401,336	9.8	9.8			52.8
44 Mifflin	138,155	135,325	273,480	45.8		45.8		
45 Monroe	152,100	170,810	322,910	52.8				
46 Montgomery	269,582	12,044	281,626	4.3	4.3			
47 Montour	59,811	15,314	75,125	20.4	20.4			30.6
48 Northampton	189,591	21,448	211,039	10.2	10.2			
49 Northumberland	184,556	82,223	266,779	30.6		30.6		
50 Perry	150,817	149,658	300,475	49.8		49.8		
51 Philadelphia	80,000	3,000	83,000	3.6	3.6			92.7
52 Pike	25,053	318,472	343,525	92.7				
53 Potter	125,951	552,939	678,890	81.4				
54 Schuylkill	400,000	137,600	537,600	25.6		25.6		
55 Snyder	132,303	66,322	198,625	33.4		33.4		54.9
56 Somerset	291,081	278,223	569,304	48.8		48.8		
57 Sullivan	121,472	147,881	269,353	54.9				
58 Susquehanna	316,801	159,231	476,032	33.4		33.4		
59 Tioga	372,345	259,356	631,701	41		41		41.1
60 Union	101,437	79,062	180,499	43.8		43.8		
61 Venango	188,658	166,096	354,754	46.8		46.8		
62 Warren	250,314	174,671	424,985	41.1		41.1		
63 Washington	422,637	64,119	486,756	13.1	13.1			26.1
64 Wayne	399,905	26,720	426,625	6.2	6.2			
65 Westmoreland	420,832	148,680	569,512	26.1		26.1		
66 Wyoming	100,337	122,642	222,979	55			55	
67 York	430,213	112,338	542,551	20.7	20.7			

Résumé.

2 counties not fully reported.

25 " have less than 25 per cent. of timber land.

27 " " more " 25 " " less than 50.

9 " " " " 50 " " " " 75.

4 " " " " 75 " "

Cleared land.....16,359,387 acres.

Timber " 9,159,826 "

Total.....25,519,213 "

25,519.) 9,159,826 (35.9% nearly,

or 9-25 nearly.

Thirty-five 9-10% of the land reported in timber.

From the above it will be seen that there are fifty-two counties whose area of timber land is less than fifty per cent. of that of the county. There are of these, seventeen whose area is less than twenty per cent. of the entire area of the county.

On the other hand, there are four counties where the area remaining in timber is at least seventy-five per cent. of the entire acreage of the county.

The assessors' reports do not represent the entire acreage of the counties as a rule. They are also faulty, or rather misleading, because much of what is there classified as timber land is not such in any present productive sense. Union and Mifflin counties are good illustrations. This remark is not designed to cast any discredit on their work. There are good reasons why they could make no nearer approach to an exact statement, and the wonder is that they have done so well. From four of the counties no exact report has been had. It is quite clear that of this thirty-five per cent. not less than one-fourth is producing nothing that should be called timber.

III. CONFIGURATION OF THE STATE IN RELATION TO THE GROWTH OF TIMBER.

In the present condition of affairs, in this Commonwealth, it is safe to assume that land which is too poor to yield remunerative crops had better be devoted to the growth of something else than the growth of cereals, or to put the proposition more broadly, agriculture on such ground does not pay. To this one may add another proposition which comes partly as a sequence of the first: *i. e.*, that land so steep as to be farmed at a disadvantage, unless it is specially adapted to grazing, tending to become impoverished by the washing away of the elements of fertility, and requiring constant restorative measures, is not remunerative under ordinary agriculture and therefore should be restored to growth of timber. It is to be observed that these statements are made not as a basis for any State interference, but merely as suggestions for the individual land owner.

The most important timber trees of this State are white pine, hemlock,

white oak, rock oak, pitch pine, shellbark and pignut hickory, black walnut, locust and chestnut. Of these the white pine is a tree of wide geographical range, and of equally wide powers of adaptation to conditions of soil and climate. Originally it grew more or less commonly through the State from the northern to the southern boundary, and most abundantly along the central meridian. It is especially noteworthy that though its favorite locality was on the higher, poorer soils, where, when once cleared, the land had little agricultural value, that it still grew luxuriantly on some of the lower, richer lands. What the original rate of reproduction over most of its area was cannot now be answered with certainty. It is, however, safe to say that on the soil best adapted to its growth in the central part of Pennsylvania, one may expect to see a tree of this species grow in from fifty-five to sixty-five years to a diameter at two feet above the ground of from eighteen to twenty-two inches. Such timber is not mature. An inspection of the stump of one felled at this age will reveal the fact that the tree was then in the most productive period of its growth, and hence that it was poor policy to sacrifice it then.

The hemlock prefers the rocky sides of our mountain gorges, or a rocky hillside overlooking a stream. Occasionally it appears in a deep forest on a flat by a stream. It is very scarce along the southern border of the State except in the mountains proper, where it extends its range to the south.

If it were required to select a single tree which should be peculiarly representative of Pennsylvania the hemlock would probably most fully be so. Here to a greater extent than in any other State it has been an important tree in our lumbering interests, and no less important in the manufacture of leather. Here also its most reckless destruction has been witnessed; where miles of matured hemlock forest have been absolutely sacrificed for the bark alone. In this State also there are probably more miles suited to reproduction of hemlock than in any other Northern State. In some respects the hemlock is peculiar; for example, the nurseryman finds no great trouble in raising it, growing it into hedges or even into isolated trees. Yet the experience of our lumbermen and the few who have tried to restore it as a forest tree has not been encouraging. Of course there are reasons for the different results, mainly due to the fact that the forester works under conditions which are inimical to its growth and which, to a large extent, the nurseryman can avoid. Still the fact remains that the hemlock is among the slowest of our forest trees in its early growth, and when the shade under which it originally grew is destroyed the difficulties of its reproduction are immensely increased. It is, however, of the utmost importance to the Commonwealth that its restoration be attempted, first, because of its intrinsic value; second, because it grows and thrives on land which, but for it, would be almost valueless. The hemlock is, as a rule, a tree having but little tap root. Its roots spread out along or just beneath the surface of the soil. Yet as one of the biological marvels connected with this wonderful tree, it will often be

found attaining its most vigorous growth and size on a rocky hillside where there is almost no soil in sight. Of course it is clear that under such conditions it must have departed from its usual rule and sent its roots deeply down beneath the surface.

The white oak would probably come next in popular esteem. It is, however, fairly a question whether the rock oak is not of greater commercial importance to this State. The best white oak, as regards both strength and durability, contrary to the general opinion, comes from the rich alluvial lands. To the truth of this proposition both science and the most intelligent experience testify. Probably of all our important forest trees, no species is more readily grown than the white oak. Mere altitude (so far at least as our State is concerned) appears to be no obstacle to its growth. We find it at the level of tide and also at an elevation of two thousand feet and upwards. It will flourish along the mountain sides, then suddenly disappear as you reach the steeper, rocky slopes, where the rock oak by its abundance gives character to the forest. It can hardly be supposed that altitude alone has been the determining cause of its disappearance. The statement has already been made that white oak from higher, poorer soil was of inferior quality, and this may indicate such a lack of physical vigor as makes it unable to cope with the hardier rock oak and locust which abound on such situations. Some of the most thrifty young white oak groves I have found in this State have been between the altitudes of one thousand and seventeen hundred feet above the sea level. In such situations the soil, however, was loamy, and with so few rocks that, once cleared, it might well enough have served for agricultural purposes. On the mountain slopes, just at the foot of the steeper incline, where there is an accumulation of loam washed from the heights above, the growth of white oak is often the most vigorous. This fact seems to obtain in our State without regard to altitude, and points again to the conclusion that for the most successful growth of this species, a fertile, comminuted soil is of the first importance.

Rock oak, locust and chestnut form, in one sense, a group by themselves—that is they agree markedly in certain peculiarities of habit, being always found associated under certain conditions, and yet on the other hand each able to thrive under conditions which would be inimical to the best development of the other. For example, they all may be expected to grow in association along those mountain slopes where the Medina and Oneida sandstones appear; neither altitude nor the rocky masses seem to prevent their growth. Yet the limestone almost certainly exercises a limiting influence on the chestnut and possibly on the rock oak, while the locust often becomes a very large tree on limestone soil.

The pitch pine may be regarded as a tree of pliant constitution. Its most constant home is on the higher mountain areas of the State. It is, however, to be observed that the reason why it now appears most frequently there is simply because it has been largely extirpated from all

other sites. The mountain tops are its remaining strongholds. It is, however, also found growing in the sands of the seashore.

The hickories (shellbark and pignut) are trees of lower ground. The former seldom leaves the alluvial flats, and though the latter is often found on the higher grounds, it seldom reaches the mountain top. Were it not for the fact that Eastern North America is the only natural home of our most valuable hickories it would hardly be worth while, or fair, to place them among our most important trees. In fact their approaching scarcity in connection with their easy reproduction is their strongest claim to notice here. As a rule all the species of hickory demand a good soil—even though it may be on a hilly surface.

Black walnut has been of importance. It is practically exhausted now. During the season's travel I have seen almost none remaining that was fully matured.

The white walnut grows along streams even high up on the mountain side, but the black walnut seldom is found in a thriving condition among the rocks of the higher, steeper slopes. This tree (black walnut) appears to grow equally well on limestone soils and on alluvial flats. Though it seems to be as averse to the Oneida and Medina sandstone regions as the rock oak, chestnut and locust are partial to them.

IV. RATES OF GROWTH OF MOST IMPORTANT KINDS OF TIMBER.

The rates of reproduction and of growth in this country are both a surprise to a foreign forester. It is with the latter of these that we are chiefly concerned, for the mere reproduction of seedlings is, as a rule, so vastly in excess of what the ground can support that the question is narrowed down to rate of growth of the surviving trees.

It is fair to lay down the general propositions that growth in height of our more important species is mainly a question of environment, and that wood production attains its yearly maximum about the close of the second third of the average life of the tree.

The first of these important propositions bears probably less upon the weight of the adult tree than it does on the character of the main trunk and on the spreading of the more important branches; in other words, that the towering white pine, white oak, or tulip poplar which has grown up in a dense forest has probably about the same quantity of wood in it that the more spreading specimens of the same species would have when grown in more open ground.

To illustrate the importance of the second proposition, that the maximum wood production is about the close of the second third of the tree's life, let us for a moment consider the relative values of one-fourth of an inch of new wood around a stem whose diameter is six inches and one whose diameter is twenty-four inches, the proportion would be as eighteen is to seventy-two, or to reduce it to a decimal, the annual wood production of the smaller stem would be but twenty-five per cent. of the larger.

There is no species of tree whose rate of growth is independent of environment. In Germany fifty cubic feet of wood is reckoned a large annual production for an acre. In this country there are abundant facts to prove that from one hundred to one hundred and twenty-five cubic feet is not unusual for the same time and on a like area.

To bring the question to a more practical presentation, it is fair to say that the average annual growth of a white oak on our mountain sides is between one-sixteenth of an inch and one-eighth. A tree of the same species growing on the alluvial flats of the lower Delaware or Susquehanna would show an average year's growth of from one-eighth to one-fourth of an inch. The rock chestnut oak on the rocky side of a mountain will probably require from eighty to one hundred years in Pennsylvania to attain a diameter of one foot. The same species of tree I have known to reach the same size in forty-five years on better soil. Our common black oak illustrates the same principle in the lifetime of one and the same tree. Thus there are specimens in Centre county which grew with the average rapidity of the species for, say, forty years and then suddenly ceased to grow and began to die at the top because their roots had reached a bed of limestone just beneath the surface of the soil. So, too, I have in mind specimens of white and scarlet oak, which, under favorable conditions, kept pace in growth with sugar and silver maples near which they were planted.

A second growth, sprouting from vigorous stumps, develops much more rapidly than the original growth where the roots were smaller in proportion to the trunk. This explains the peculiar strength and value for certain mechanical purposes of the second-growth white oak in the rich lands of Indiana and Illinois. It is simply an illustration of the statement already made that the larger year's growth made a better lumber than the smaller (in the same species).

As a rule, we may say that a century will be required to mature white pine, hemlock and the hickories. The oaks will require half as much longer time. Chestnut may be regarded as making a fair body of mature wood in seventy-five years.

V. OBSTACLES TO THE GROWTH OF TIMBER.

(a) *Natural Obstacles.*

These have been in part anticipated by the statements already made. Among these poverty of soil may be regarded as first in importance. This, however, is connected with an induced poverty due to removal of an earlier forest growth whereby on the steeper slopes the soil is washed away more rapidly than it is renewed. Indeed, one philosophical observer has stated that if the forests were removed from our Pennsylvania mountains and they allowed, for any considerable time, to remain without trees, that reforestation would be practically impossible. Whether this statement is, or is not, true as a scientific principle, it may at least be

allowed that the difficulties of producing a new forest growth would be infinitely increased. Fortunately we are, to a very great extent, exempt thus far from the fungal and insect foes which have produced such serious havoc in Central Europe. It is, however, within the limits of probability that there may come a time when this immunity will cease. For example, in the Adirondacks certain of the cone-bearing trees have to a limited extent been injured by the fungus which produces the clustered branches known as "witches' brooms;" and in Fulton county of this State, one or more small species of beetles have within the last three years killed considerable bodies of pitch pine by burrowing beneath the bark and destroying the young cambium layer on which the life of the tree depends. It is estimated that in West Virginia these same insects have destroyed \$1,000,000 worth of timber in the last four years.* It is interesting to note that an insect antagonistic to these beetles has been found in considerable numbers on the infested trees. To what extent they may succeed in holding the beetle in check remains to be seen. The most promising plan of treatment would seem to be to cut and burn every infested tree. The fact that thus far the insect invasion has been slow and affecting only isolated clumps indicates the possibility of successfully heading it off if dealt with promptly.

The natural tendency in this State is towards a spontaneous reproduction of forests. This shows that the obstacles are neither numerous, nor grave in character.

(b) *Obstacles Due to Human Agencies.*

The chief obstacle here is fire—operating now in one way and now in another—and caused by design, often with malicious intent, or by accident on the part of an individual, or by a passing train.

Fire acts directly and indirectly to prevent the growth of timber.

Thus directly it kills the seeds, saplings, and often mature trees, such as the hemlock and the white pine.

The most destructive fires are those which follow close upon the operations of the lumberman. The débris left by him invokes the flame and furnishes the requisite fuel for it, when once created. One severe conflagration, especially if on a steep hillside, may not only blight the promise of a coming crop of trees, but may lead to the destruction of the soil to such an extent that almost no plant life can flourish. And year by year the little remaining soil is carried away by the descending rain until restoration of forest growth seems almost impossible. Instances of this condi-

* This note from Mr. Charles W. Johnson explains itself:

"There are several species of beetles destructive to the pines of West Virginia. The principal ones are *Dendroctonus frontalis* or 'The Destructive Pine Bark Beetle,' *Tomicus calligraphus*, and *Tomicus cacographus*, the latter is the one we found in Fulton county. The Clerus imported from Europe is the *Clerus formicarius*, 'European Bark Beetle Destroyer.' The one we found in Fulton county is closely allied and is known as *Thanasimus dubius*."

tion occur near the head of Long Run, in Clinton county, and in portions of the Beech Creek region in Centre and Clinton counties.

Fires are frequently created to destroy the young timber and to encourage the growth of grass for summer pasturage for cattle. The writer saw one such instance during the past season where a most valuable body of young white pine was destroyed, and it seemed morally certain that it was by a fire started in the interest of a score of vagrant cattle. Of course the remedy for such a state of affairs might be prompt and sure. Confiscation of such cattle, by due form of law, when found without permission on land of other parties would end once for all this burning. There can be no doubt that a considerable percentage of forest fires is the result of absolute maliciousness. Luzerne county of this State, but a few years ago, furnished numerous examples of what were doubtless to be attributed to this cause. The cure here is by no means so simple as at first appears. The remedy which seems most popular at present, not only in this, but other States, *i. e.*, authorizing supervisors, or other officers, to call out men to suppress forest fires and paying them for their work, has been found by actual trial in several counties of this State to be an inducement to create fires on unseated lands. It is a humiliating admission, but it is clear that those and other regions of our own Commonwealth are not sufficiently law-abiding, or observant of ethical principles, to make this method practicable. The enactment of rigid and severe penal statutes is a matter of doubtful value, unless accompanied by a costly machinery to ferret out and bring offenders to justice. Opening of fire lanes through the timber lands raises the question by whom shall it be done—at individual or at State expense? The same may be said of keeping them open. There can be no doubt that well-kept fire lanes do render suppression of such fires more easy, even if they do not interpose a certain barrier to their spread. It will probably become more and more clear that timber protection and production in this State will be effective and common just in proportion as it is made to the interest of the individual citizen to guard and plant trees. Here we come back to the most general of all principles under a popular government, that laws are strong and effective only when backed by public sentiment, and this may only be surely attained by an appeal to individual interests. This brings me to

VI. RELATION OF THE COMMONWEALTH TO FOREST RESTORATION.

The first duty of government is either to perpetuate itself or to lead up to some higher, better form of government. On this hangs not only the safety of vested rights and the safety of capital, but the strongest incentives to individual thrift, industry, economy and rectitude are found in the idea that property acquired may be transmitted under protection of a stable government. There is no crime more unpardonable in the individual than the treason which strikes at the safety of the government. Is the act by which the State endangers its own prosperity and perpetuity

any less heinous? This reduced to its simplest terms is the issue now before the Commonwealth. Already after but two hundred and fifty-six years of civilized occupancy, Pennsylvania is called upon to interfere in order to restore to a productive condition, and to protect against extravagant use, about one-eighth of her area. Failure to act promptly now, and wisely, will entail on the coming generation loss of resource, individual suffering and increase of taxation to meet the demands of pauperism. These propositions seem so clear in the light of present resources and prospective population that it is a waste of words to discuss them.

There are, at least, three thousand square miles in this State to-day whose only possible function is the production of timber. There is, at least, an equal area of land now cleared, impoverished and becoming poorer each year, on which cultivation has been attempted, and proven hopelessly unremunerative, which should be covered again by a forest growth. No other proposition promises anything. Unless these six thousand square miles are kept in a productive condition they will be an absolute loss to the State and a continued menace to much of the productive farming land.

The problem is one of great magnitude. Two and only two lines of public policy are possible. The first one is for the State to assume control of such areas. The second is for the individual to be encouraged to make these areas productive under the stimulus of State direction and State aid. Which shall it be?

Where an area is distinctly isolated, and as yet in an unimproved condition in great part, on general principles it might be wiser for the State to assume direct and absolute control of it, because a far-reaching policy could be inaugurated which would look to the largest results ultimately. The necessity for such action would be more and more apparent if it could be shown that it was directly in the interest of the Commonwealth that the State should be the possessor of the land.

The State of New York undoubtedly is in that position to-day. The wisdom of her acquiring an absolute right to the Adirondack region by just and legal extinguishment of all individual titles, will depend upon no other condition than what use she makes of the land.

The State of Pennsylvania is not so fortunately situated. Her natural timber areas extend clear across from the northern to the southern border and almost bisect her territory. Important railway lines run through her belt of natural timber lands. Large rivers traverse them and thriving farms, villages and towns occupy the choicer parts of these areas, which as a whole may be designated as almost exclusively natural woodlands. Clearly the State could acquire no righteous title, nor could she, even if ownership were possible, administer an estate so broken and disconnected in an economical manner.

The remaining alternative is to recognize the fact that protection and utilization of these regions is of the first importance to the Commonwealth and to make it the interest of the citizen to serve the State. To this

proposition it is thought no one will object. But at present the State and the individual are absolutely at cross purposes so far as the timber lands are concerned. The township demands taxes for a protection which is not accorded : for improvements which it does not make and for profits which the owner does not receive. The facts are at hand to show that in certain portions of the State, timber land, which has yielded the owners nothing for thirty years, has in that period paid more in the way of taxes than the land could be sold for to-day. Is it strange that to save themselves, the owners of such lands should remove the timber and realize what they can, then abandon them rather than pay the taxes? This same timber would be worth much more to the owner if allowed to stand. The township which drives the man to remove this timber, then to abandon the land, loses at once taxes for present use, and resources of future value. It requires no argument to prove that this is a false policy.

We will briefly consider the results of a removal of taxes from timber land.

In the first place it would confer new value on these lands. Owners would, instead of wholly abandoning them, at least retain them. Retaining them, even uncared for, there would something of value grow upon them. Here and there a tree, often a young growth of forest trees ; and what was of no value would come now to have a positive value, however small. The owner would have an interest, and what applies to the individual owner would apply to the community, and the man who by accident or by design fired land which was producing something and costing nothing would soon be a marked person. Public sentiment instead of looking almost with indifference on woodland fires would become actively interested in their suppression. Fire laws would have, what they do not now have, support ; and the law which hitherto was a dead letter would become a living, real thing. So much gained as timber was becoming scarcer, the next inevitable step would be to increase the quantity of timber produced, to improve its quality and to diminish, so far as possible, the time required to mature it, as well also as to make the maturing forest pay for its own maintenance.

Here we have at once the germ of a forestry system. It would have the further advantage of being a system developed in harmony with our own environment. It is probable that in a quarter of a century we should be further on towards success than if we tried to adopt and adapt a foreign system to the conditions of a popular government.

Not only would the steeper, rocky hillsides respond productively to this new policy, but at once another element would enter the problem. Lands hitherto taxed as farm lands, but which were unremunerative, under cultivation would be planted in trees. And from being costly unproductive lands, become productive lands entailing no cost. The barren hillsides of this generation would have their virgin fertility partly restored and by the time they were required to produce crops for the larger population half a century hence would be in condition to do so. Then, when

the average farms have become reduced in size and a better system of agriculture inaugurated, we might hope they would be prevented, even if cleared, from relapsing into the unproductive condition in which they are found now. Probably by that time timber growing as a legitimate branch of agriculture would be established among us, and they would be found to pay enough to warrant keeping them in timber.

There are, however, two sides to this question. The Constitution of this State reads thus: "*Art. iii, Sec. 7.* The General Assembly shall not pass any local or special law exempting property from taxation."

It furthermore, *Art. ix, Sec. 1*, expressly declares "that all taxes shall be uniform upon the same class of subjects within the territorial limits of the authority levying the tax, and shall be levied and collected under general laws: but the General Assembly may by general laws exempt from taxation public property used for public purposes, actual places of religious worship, places of burial not used or held for private or corporate profit, and institutions of purely public charity.

"*Sec. 2.* All laws exempting property from taxation, other than the property enumerated, shall be void."

It will be seen from this that as timber lands are not in the favored classes their exemption from taxation was clearly forbidden.

The Constitution, however, distinctly recognizes the constitutionality of classification in persons and things to be taxed. *Art. ix, Sec. 1*, already quoted, expressly declares for it in the phrase "all taxes shall be uniform upon the same class of subjects."

It may be an open question whether or not it may be possible to claim exemption from taxes for timber lands on the ground that as they collected water from the State at large, as they aided in retaining the fertility of the soil on land other than that of the forest owner, they were in fact and deed "objects of purely public charity, or lands used for public purposes;" until the owner derived a revenue from them by the removal and sale of wood. It is, however, clearly within the power of the General Assembly to place them in a class by themselves under a specified minimum rate of taxation, because they are under different conditions of production and are wholly different from any other lands, and for the good of the Commonwealth require legislation different in character from any other lands. "Laws enacted in pursuance of such classification and for such purposes are, properly speaking, neither local nor special." It is equally clear that if tax were collected from such lands classified as a separate class it would be under a general law, which specified no individual, but dealt with a whole class of persons, all of whom were similarly conditioned.

Then again, even if tax were removed, or greatly reduced, on timber lands the whole problem would not be solved, because this would deprive many portions of the State, where an excess of timber over cleared land remains, of the funds required for current expenses. This difficulty is a serious one, and unless the deficit be made good, would be an absolutely

prohibitory objection to total or partial exemption of timber lands from taxation.

Let us consider this problem from another point. The water which turns our factory wheels and which is used by our larger towns and cities; whence does it come? As a rule, from forest-covered hillsides in remoter parts of the State. The mills, towns and cities seldom pay anything for it until it reaches their seats. The men who own the land pay the taxes and receive actually less from it than those who pay nothing for it. Put the proposition in its baldest form: The City of Philadelphia pays nothing for an element which is essential to its life and without which it could not endure a day until it reaches the city limits. Another portion of the community is taxed that we may receive our water free. Is this fair? The comparisons between air and water supply are not parallel. No one is taxed for air, we simply ask that these cases be made parallel by taxing no one for production of water. It is not too much then to say that the State at large is the beneficiary of the woodlands. Nor is it too much to ask that legislation be granted by which such counties of the State as endure a hardship by removal of taxes from their timber lands should be relieved by the State to the extent of their financial loss from this cause.

When timber comes to be removed it ceases to be a purely public benefit. It enters the domain of individual or corporate trade and should be taxed accordingly.

It is becoming more and more clear that officials are required whose duty it shall be to direct suppression of fires, and to ferret out offenders. The law should be imperative that every magistrate in the Commonwealth should report through proper channels at each session of Court all he knows of forest fires since previous session. It should be made a specific duty, to any evasion of which a penalty in some form should be attached. The State already allows annually a premium on trees planted thus: For 1200 to the acre during the first ten years ninety per centum of the tax paid on the same ground, providing said premium shall not exceed the sum of forty-five cents per acre. For the second period of ten years the premium is eighty per centum, providing that the premium shall not exceed the sum of forty cents per acre.

For a third and final period of ten years the premium shall be fifty per centum, providing that the premium so paid shall not exceed the sum of twenty-five cents per acre.

During and after the second period of ten years, the land owner may thin out his trees to not less than 600 per acre "so long as no portion of the said land shall be absolutely cleared of the said trees."

Nurserymen or other tree salesmen are not included in the benefits of this act.

Timber land which has been cleared may receive the same premium as above indicated, providing that notice has been given within one year from date of clearing of the owner's intention to maintain said land in

timber ; the number of trees per acre required is the same, and, on the other hand, the privilege of thinning is the same as to time and number.

It is quite remarkable that so few of those who might have taken advantage of this law have been aware of its place on the statute book. The Commissioners of Schuylkill county have, however, paid to the Girard estate money due under the provisions of this act. The precedent is therefore established, and others may be expected to avail themselves of the benefits offered.

It will be seen, however, that liberal as these premiums are, they fail at the very period when there begins to be a temptation to cut, and when the average tree is in the state of its greatest productiveness, so far as the growth of wood is concerned. The woodland owner may keep his domain constantly in condition to earn the government premium ; but he will produce no thoroughly good-matured wood if he is encouraged to cut it at thirty years of age.

These bounties mark an important advance in public sentiment on the forestry problem ; but they fall far short of the full measure of usefulness one might expect from a complete remission of taxes, when such remission is based on an appreciation of the fact that public rather than private interest is most subserved by it.

It is clear that the question of an extensive State Forest Reservation is one which cannot be much longer postponed. That this is demanded not less in the interest of a pure, abundant water supply than it is by the ordinary interests of forestry is no less clear ; and it almost follows as a matter of course that such reservation should be located on the watershed which supplies the largest quantity of pure water to the largest population. In this view of the matter, the spot where such reservation should be is plainly indicated by the topography of the State. It should be noted further that this reservation might be made equally available as a public sanitarium. It cannot be too strongly or too often noted that it is a measure of wise statesmanship, to provide an outing ground where those who are physically below par may by a sojourn in the open air of a wholesome region find renewed strength for the duties of life. This is suggested not on any basis of philanthropy or sentiment, but simply because it promises to reduce the number of those who otherwise might become charges on the Commonwealth.

VII. METHODS OF FOREST RESTORATION.

This division might come more properly in a treatise on practical forestry. Still it may be proper to make certain general statements here on the subject. So far as known, there are at present within the limits of the State but two areas which might with any degree of propriety be designated as illustrating forestry practice. Both of these are managed as a portion of the City Trusts, and are located one in Schuylkill and the other in Centre county.

Forest restoration in this Commonwealth should be mainly confined to two classes of ground—first, that which is fit for nothing else and otherwise would be unproductive, and second, that which is worn out by unproductive agriculture, and which would be more promptly and cheaply restored to virgin fertility by a return to primitive conditions. It is probably a safe estimate, as already indicated, that there are not less than six thousand square miles of territory which belong to one or the other of these classes ; or to put the statement in another way, about one-eighth of the area of the State.

It is well to urge, that for the present and the immediate future, public or private forest operations of a restorative character should be confined mainly to such native forest trees as make the most certain and speedy growth. This would not necessarily exclude such trees as the oaks, for under favorable conditions these may be classed as rapid growers when compared with related trees elsewhere.

The most promising of the native trees would be white pine, chestnut, locust, black walnut ; and on rich soil, shellbark, hickory and white oak. Hemlock culture will eventually become a necessity to the Commonwealth, but owing to its slow growth and its uncertain success had better not at present be urged. White oak is a tree of wide growth and therefore not so immediately in danger of becoming below our actual wants in quantity. Chestnut grows freely over a wide range of conditions ; in other words, its natural tendency is to take care of itself. These facts make white pine the one tree whose immediate culture is most promising and most needed. How shall its restoration be most successfully undertaken ? There are two methods, which we may properly designate as the nursery method and the method in final position. The former is probably not soon likely to become popular. Hence the latter method is the one most certain to lead to successful results in this country. The young trees of this species are sensitive, as most cone-bearing trees are, to excess of sunlight. It should be started under the shadow of an existing open forest cover which is soon to be removed. To meet this condition, white pine seed should be sown, when possible on a northern exposure, in poor, or at least, in rather poor soil. The mature cones may be gathered in the autumn, kept in a cool dry place until spring, when many of the winged seeds will be found to have escaped from the cones. The remainder may be obtained by shaking or breaking the cones. Early in the spring, the sooner after the frost comes out of the ground the better, the leaves of the open woods should be lightly raked from the soil, in spots, so as to give the seeds a chance to come in contact with the soil, or at least with the damp leaves. Then cover the seeds lightly with a rake. This is rendered necessary by the fact that though the seeds of the white pine are well enough adapted to dispersion, they are not so well suited to self-planting, and many must fail of growth because they do not come in contact with a suitable substratum. When the young pines are three or four

years old the sheltering forest will have done its work and may be removed at any time.

It should be remembered that the cone-bearing trees are social in character and hence do better in dense groves. In fact, one may also say dense planting is an essential condition upon which rests the production of the best pine timber. It is probable enough that starting white pine in nurseries will some day come to be here, as elsewhere, the more common method, but it involves too much labor and care to recommend it at this stage of the Forestry Idea in the United States, or certainly, at least, in Pennsylvania.

Black walnut will always have a special value, and to make the idea more clear, it should be added that this value will depend on the character of the individual log. There are in this State thousands of acres of fertile river bottoms where agriculture has been practically abandoned because of the frequently recurring freshets, on which the black walnut would not only grow rapidly, but where it might be depended upon to produce a good quality of lumber. This tree does not, at first, grow rapidly on a soil of stiff limestone clay.

There is no surer way of starting the black walnut than to allow the fruit to remain out over winter under a slight cover of leaves. When spring comes it will probably be found that the frost has opened the fruit so that a prompt start that spring may be expected. As the black walnut does not bear transplanting well, it is better that the nuts should be planted where they are to remain.

All that has been said of the method of starting the black walnut applies to the shellbark and hickory as well.

The white oak is worthy of a moment's consideration. It grows with great certainty from good acorns, and may be planted in drills as soon as collected. If one thinks it really worth while to have his trees in the best condition for a vigorous start when finally transplanted, it is a good policy to lift and replant the young oaks at least twice before they are placed in permanent position. Good soil should be insisted upon as a cardinal point in white oak planting. If poor soil is to be occupied by oaks let the planting be of rock oak, providing the soil is well drained. All that has been said as to starting the white oak applies as well to starting the rock oak. The same may be said of the chestnut.

Our common locust tree, it is not generally remembered, is a native of the mountain sides of this State. This fact should suggest the extreme value it possesses in reclothing those steep, poor regions with a timber whose value will always be appreciated. It has the further fact in its favor, once fairly started, it resists better than almost any other species of our trees, the periodical scorchings it receives from the spring and autumn fires.

Further consideration of this topic from the practical standpoint would be out of place here.